

**CLAIMS**

We claim:

1. A modular inductively coupled plasma torch assembly comprising:

a tubular plasma chamber having an outer surface defining an outer diameter;

a tubular jacket having an inner surface defining an inner diameter larger than said tubular plasma chamber outer diameter; and

detachable first and second connector units positioned on opposite ends of said tubular jacket so as to hold said tubular plasma chamber concentrically within said tubular jacket and define an annular chamber between said tubular plasma chamber outer surface and said tubular jacket inner surface, wherein said detachable first connector unit includes an inlet port fluidically coupled to said annular chamber and said detachable second connector unit includes an outlet port fluidically coupled to said annular chamber so as to allow a flow of coolant to pass through said annular chamber to cool said tubular plasma chamber outer surface.

2. The modular inductively coupled plasma torch assembly according to claim 1, further comprising an inductor coil disposed concentrically around said tubular jacket.

3. The modular inductively coupled plasma torch assembly according to claim 1, wherein said detachable first connector unit comprises:

first large and first small O-rings, wherein said first large O-ring has an inner diameter suitable for fitting around an outer diameter of said tubular jacket and said first small O-ring has an inner diameter suitable for fitting around said tubular plasma chamber outer diameter; and

a first connector having large and small diameter ends, wherein said tubular jacket is positioned concentrically within said large diameter end and held in that position by compressing said first large O-ring so as to apply a force against an outer surface of said tubular jacket, and an exposed portion of said tubular plasma chamber is positioned concentrically within said small diameter end and held in that position by compressing said first small O-ring so as to apply a force against said outer surface of said tubular plasma chamber.

4. The modular inductively coupled plasma torch assembly according to claim 3, wherein said detachable first connector unit further comprises a first large cinch nut screwed into outer threading of said large diameter end of said first connector so as to compress said first large O-ring.

5. The modular inductively coupled plasma torch assembly according to claim 4, wherein said detachable first connector unit further comprises a first large seal

ring configured to compress said first large O-ring against a tapered wall of said large diameter of said first connector when said first large cinch nut is screwed into said outer threading of said large diameter end.

6. The modular inductively coupled plasma torch assembly according to claim 5, wherein said detachable first connector unit further comprises a first large slip washer ring inserted between said first large seal ring and said first large cinch nut so as to inhibit torque applied to said first large cinch nut from being transferred to said first large O-ring.

7. The modular inductively coupled plasma torch assembly according to claim 3, wherein said detachable first connector unit further comprises a first small cinch nut screwed into outer threading of said small diameter end of said first connector so as to compress said first small O-ring.

8. The modular inductively coupled plasma torch assembly according to claim 7, wherein said detachable first connector unit further comprises a first small seal ring configured to compress said first small O-ring against a tapered wall of said small diameter end of said first connector when said first small cinch nut is screwed into said outer threading of said small diameter end of said first connector.

9. The modular inductively coupled plasma torch assembly according to claim 8, wherein said detachable first connector unit further comprises a first small slip washer ring inserted between said first small seal ring and said first small cinch nut so as to inhibit torque applied to said first small cinch nut from being transferred to said first small O-ring.

10. The modular inductively coupled plasma torch assembly according to claim 7, wherein said detachable second connector unit comprises:

second large and second small O-rings, wherein said second large O-ring has an inner diameter suitable for fitting around said outer diameter of said tubular jacket, and said second small O-ring has an inner diameter suitable for fitting around said tubular plasma chamber outer diameter; and

a second connector having large and small diameter ends, wherein said tubular jacket is positioned concentrically within said large diameter end and held in that position by compressing said second large O-ring so as to apply a force against said outer surface of said tubular jacket, and a second exposed portion of said tubular plasma chamber is positioned concentrically within said small diameter end and held in that position by compressing said second small O-ring so as to apply a force against said outer surface of said tubular plasma chamber.

11. The modular inductively coupled plasma torch assembly according to claim 10, wherein said detachable

second connector unit further comprises a second large cinch nut screwed into outer threading of said large diameter end of said second connector so as to laterally compress said second large O-ring.

12. The modular inductively coupled plasma torch assembly according to claim 11, wherein said detachable second connector unit further comprises a second large seal ring configured to compress said second large O-ring against a tapered wall of said large diameter end of said second connector when said second large cinch nut is screwed into said outer threading of said large diameter end of said second connector.

13. The modular inductively coupled plasma torch assembly according to claim 12, wherein said detachable second connector unit further comprises a second large slip washer ring inserted between said second large seal ring and said second large cinch nut so as to inhibit torque applied to said second large cinch nut from being transferred to said second large O-ring.

14. The modular inductively coupled plasma torch assembly according to claim 10, wherein said detachable second connector unit further comprises a second small cinch nut screwed into outer threading of said small diameter end of said second connector so as to compress said second small O-ring.

15. The modular inductively coupled plasma torch assembly according to claim 14, wherein said detachable second connector unit further comprises a second small seal ring configured to compress said second small O-ring against a tapered wall of said small diameter end of said second connector when said second small cinch nut is screwed into said outer threading of said small diameter end.

16. The modular inductively coupled plasma torch assembly according to claim 15, wherein said detachable second connector unit further comprises a second small slip washer ring inserted between said second small seal ring and said second small cinch nut so as to inhibit torque applied to said second small cinch nut from being transferred to said second small O-ring.

17. The modular inductively coupled plasma torch assembly according to claim 2, further comprising a detachable rear connector unit positioned at a rear end of said tubular plasma chamber, wherein said detachable rear connector unit includes a first inlet port fluidically coupled to an interior of said tubular plasma chamber so as to allow a flow of a first material to pass through said tubular plasma chamber for generating said plasma while said inductor coil is energized.

18. The modular inductively coupled plasma torch assembly according to claim 17, wherein said detachable rear connector unit includes a second inlet port

fluidically coupled to said interior of said tubular plasma chamber so as to allow a flow of a second material to pass through said tubular plasma chamber for generating said plasma while said inductor coil is energized.

19. The modular inductively coupled plasma torch assembly according to claim 18, wherein said first and said second materials are the same material.

20. The modular inductively coupled plasma torch assembly according to claim 17, wherein said first inlet port is fluidically coupled to said interior of said tubular plasma chamber through an elongated cavity having a diameter smaller than an inner diameter of said tubular plasma chamber.

21. The modular inductively coupled plasma torch assembly according to claim 17, wherein said detachable rear connector unit comprises:

a third small O-ring having an inner diameter suitable for fitting around said tubular plasma chamber outer diameter; and

a third connector having an open end, wherein an end of said tubular plasma chamber is positioned within said open end of said third connector and held in that position by compressing said third small O-ring so as to apply a force against said outer surface of said tubular plasma chamber.

22. The modular inductively coupled plasma torch assembly according to claim 21, wherein said detachable rear connector unit further comprises a third small cinch nut screwed into outer threading of said open end of said third connector so as to compress said third small O-ring.

23. The modular inductively coupled plasma torch assembly according to claim 22, wherein said detachable rear connector unit further comprises a third small seal ring configured to compress said third small O-ring against a tapered wall of said open end of said third connector when said third small cinch nut is screwed into said outer threading of said open end.

24. The modular inductively coupled plasma torch assembly according to claim 23, wherein said detachable rear connector unit further comprises a third small slip washer ring inserted between said third small seal ring and said third small cinch nut so as to inhibit torque applied to said third small cinch nut from being transferred to said third small O-ring.

25. The modular inductively coupled plasma torch assembly according to claim 2, further comprising a detachable front connector unit including:

a fourth small O-ring having an inner diameter suitable for fitting around said tubular plasma chamber outer diameter; and



a fourth connector having first and second open ends, wherein an end of said tubular plasma chamber is positioned within said first open end and held in that position by compressing said fourth small O-ring so as to apply a force against said outer surface of said tubular plasma chamber.

26. The modular inductively coupled plasma torch assembly according to claim 25, wherein said second open end of said fourth connector fluidically couples said tubular plasma chamber to a processing chamber for processing at least one semiconductor wafer.

27. The modular inductively coupled plasma torch assembly according to claim 25, wherein said detachable front connector unit further comprises a fourth small cinch nut screwed into outer threading of said first open end of said fourth connector so as to compress said fourth small O-ring.

28. The modular inductively coupled plasma torch assembly according to claim 27, wherein said detachable front connector unit further comprises a fourth small seal ring configured to compress said fourth small O-ring against a tapered wall of said first open end when said fourth small cinch nut is screwed into said outer threading of said first open end.

29. The modular inductively coupled plasma torch assembly according to claim 25, wherein said second open end has a smaller inner diameter than said first open end of said fourth connector.

30. The modular inductively coupled plasma torch assembly according to claim 25, wherein said detachable front connector unit includes a third inlet port fluidically coupled to said interior of said tubular plasma chamber and configured so as to allow a third material to flow back towards a rear end of said tubular plasma chamber while said inductor coil is energized to generate said plasma.

31. The modular inductively coupled plasma torch assembly according to claim 30, wherein said third inlet port is fluidically coupled to said interior of said tubular plasma chamber through a first flared channel so that said third material initially flows back at an angle towards said rear end of said tubular plasma chamber.

32. The modular inductively coupled plasma torch assembly according to claim 30, wherein said detachable front connector unit includes a fourth inlet port fluidically coupled to said interior of said tubular plasma chamber and configured so as to allow a fourth material to flow back towards said rear end of said tubular plasma chamber while said inductor coil is energized to generate said plasma.

33. The modular inductively coupled plasma torch assembly according to claim 32, wherein said fourth inlet port is fluidically coupled to said interior of said tubular plasma chamber through a second flared channel so that said fourth material initially flows back at an angle towards said rear end of said tubular plasma chamber that is different than said third material flow.

34. The modular inductively coupled plasma torch assembly according to claim 33, wherein said third and said fourth materials are the same material.

35. The modular inductively coupled plasma torch assembly according to claim 2, further comprising a detachable member rigidly connecting said detachable first and said detachable second connector units so as to be positioned and held on opposite sides of said tubular jacket.

36. A modular inductively coupled plasma torch assembly comprising:

- a tubular plasma chamber;

- a detachable rear connector unit held to a rear end of said tubular plasma chamber, wherein said detachable rear connector unit includes a first inlet port fluidically coupled to an interior of said tubular plasma chamber so as to allow a flow of a first material to pass through said tubular plasma chamber; and

an inductive coupling member for inductively applying energy to said material flowing through said tubular plasma chamber in order to produce and sustain plasma in the tubular plasma chamber.

37. The modular inductively coupled plasma torch assembly according to claim 36, wherein said detachable rear connector unit includes a second inlet port fluidically coupled to said interior of said tubular plasma chamber so as to allow a flow of a second material to pass through said tubular plasma chamber.

38. The modular inductively coupled plasma torch assembly according to claim 37, wherein said first and said second materials are the same material.

39. The modular inductively coupled plasma torch assembly according to claim 36, wherein said detachable rear connector unit comprises:

a small rear O-ring having an inner diameter suitable for fitting around an outer diameter of said tubular plasma chamber; and

a rear connector having an open end, wherein a rear end of said tubular plasma chamber is positioned within said open end of said rear connector and held in that position by compressing said small rear O-ring so as to apply a force against an outer surface of said tubular plasma chamber.

40. The modular inductively coupled plasma torch assembly according to claim 39, wherein said detachable rear connector unit further comprises a small rear cinch nut screwed into outer threading of said open end of said rear connector so as to compress said small rear O-ring.

41. The modular inductively coupled plasma torch assembly according to claim 40, wherein said detachable rear connector unit further comprises a small rear seal ring configured to compress said small rear O-ring against a tapered wall of said open end of said rear connector when said small rear cinch nut is screwed into said outer threading of said open end.

42. The modular inductively coupled plasma torch assembly according to claim 41, wherein said detachable rear connector unit further comprises a small rear slip washer ring inserted between said small rear seal ring and said small rear cinch nut so as to inhibit torque applied to said small rear cinch nut from being transferred to said small rear O-ring.

43. The modular inductively coupled plasma torch assembly according to claim 36, further comprising a detachable front connector unit including:

a first front O-ring having an inner diameter suitable for fitting around said tubular plasma chamber outer diameter; and

a front connector having first and second open ends, wherein an end of said tubular plasma chamber is positioned within said first open end and held in that position by compressing said first front O-ring so as to apply a force against said outer surface of said tubular plasma chamber.

44. The modular inductively coupled plasma torch assembly according to claim 43, wherein said second open end of said fourth connector fluidically couples said tubular plasma chamber to a processing chamber for processing at least one semiconductor wafer.

45. The modular inductively coupled plasma torch assembly according to claim 43, wherein said detachable front connector unit further comprises a first front cinch nut screwed into outer threading of said first open end of said front connector so as to compress said first front O-ring.

46. The modular inductively coupled plasma torch assembly according to claim 45, wherein said detachable front connector unit further comprises a first front seal ring configured to compress said first front O-ring against a tapered wall of said first open end when said first front cinch nut is screwed into said outer threading of said first open end.

47. The modular inductively coupled plasma torch assembly according to claim 46, wherein said second open end has a smaller inner diameter than said first open end of said fourth connector.

48. The modular inductively coupled plasma torch assembly according to claim 25, wherein said detachable front connector unit includes a third inlet port fluidically coupled to said interior of said tubular plasma chamber and configured so as to allow a third material to flow back towards a rear end of said tubular plasma chamber while said inductor coil is energized to generate said plasma.

49. The modular inductively coupled plasma torch assembly according to claim 48, wherein said third inlet port is fluidically coupled to said interior of said tubular plasma chamber through a first flared channel so that said third material initially flows back at an angle towards said rear end of said tubular plasma chamber.

50. The modular inductively coupled plasma torch assembly according to claim 49, wherein said detachable front connector unit includes a fourth inlet port fluidically coupled to said interior of said tubular plasma chamber and configured so as to allow a fourth material to flow back towards said rear end of said tubular plasma chamber while said inductor coil is energized to generate said plasma.

51. The modular inductively coupled plasma torch assembly according to claim 50, wherein said fourth inlet port is fluidically coupled to said interior of said tubular plasma chamber through a second flared channel so that said fourth material initially flows back at an angle towards said rear end of said tubular plasma chamber that is different than said third material flow.

52. The modular inductively coupled plasma torch assembly according to claim 50, wherein said third and said fourth materials are the same material.

53. A modular inductively coupled plasma torch assembly comprising:

a tubular jacket;

a tubular plasma chamber disposed concentrically within said tubular jacket so as to define an annular chamber between an outer surface of said tubular plasma chamber and inner surface of said tubular jacket, and having rear and front ends extending out of said tubular jacket;

an inductor coil disposed concentrically around said tubular jacket so as to generate plasma within said tubular plasma chamber when energized;

detachable first and second connector units positioned on opposite ends of said tubular jacket so as to hold said tubular plasma chamber concentrically within said tubular jacket and provide a flow of coolant through said



annular chamber to cool said tubular plasma chamber outer surface; and

a detachable rear connector unit positioned at said rear end of said tubular plasma chamber to provide a flow of material through said tubular plasma chamber for generating said plasma when said inductor coil is energized.

54. The modular inductively coupled plasma torch assembly according to claim 53 further comprising a detachable front connector unit positioned at said front end of said tubular plasma chamber for fluidically coupling an interior of said tubular plasma chamber to a processing chamber for processing at least one semiconductor wafer.

55. The modular inductively coupled plasma torch assembly according to claim 54, wherein said detachable first and said detachable second connector units, said rear connector unit, and said front connector unit are at least partially held in their respective positions by compressing O-rings that apply forces radiating outward and against said tubular plasma chamber outer surface.